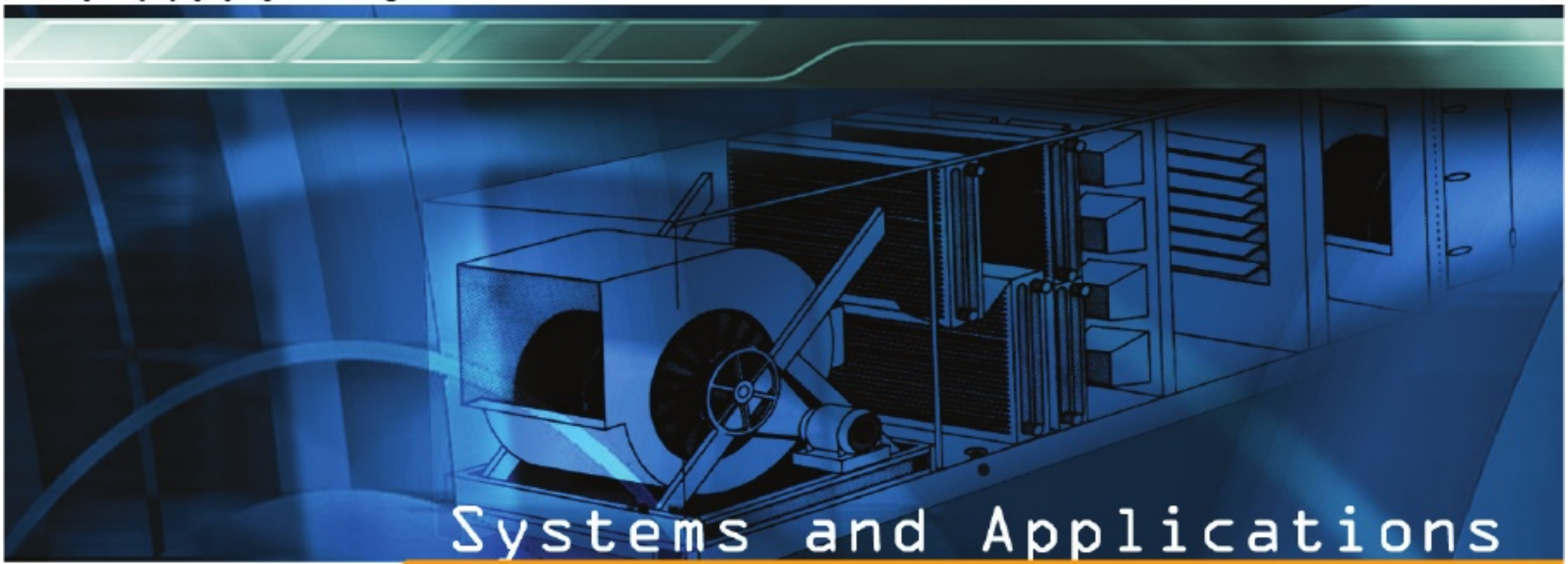
PART 9



Systems and Applications

CONTENTS PART 9 SYSTEM AND APPLICATIONS

SYSTEM DESIGN MANUAL

SUMMARY OF PART NINE

This part of the System Design Manual presents guides for selecting the air conditioning system used with specific applications.

CHAPTER 1. SYSTEMS AND APPLICATIONS

This text introduces the engineer to the preliminary considerations and project aspects for determining the selection of an air conditioning system. The part sketches the systems available and compares their performance and applicability to various spaces and buildings. It also indicates the particular problems of selected applications, stressing the important functions of air conditioning. It presents a broad review only; details of various systems and their design are presented in other parts of this manual.

SCOPE AND INTENT

Selection of the correct air conditioning system for a particular space or building is a very critical decision facing the design engineer. On this decision rests the satisfaction of the customer and occupant and the system fitness to the building it serves. Many factors must be analyzed, judged, screened and coordinated. The desires of the investor and the economic aspects are the foremost considerations.

CUSTOMER AND OBJECTIVE

There is a big gap between a customer who thinks in terms of simple relief cooling in a room or small establishment and the one who builds a monumental building representing the epitome of an integrated concept of a structure and the environment within, whether architectural, acoustical or air conditioning.

Complete air conditioning provides an environment of correct temperature, humidity, air movement, air cleanliness, ventilation and acoustical level. Anything less is a compromise and is not termed air conditioning. Therefore the particular system involved should be identified with the function which the system design is to accomplish, whether heating, cooling, humidity control or complete year-round air conditioning.

There must be complete fusion of system and building to lead to a natural and normal behavior as a whole in disposing of the heat gains or offsetting the heat losses.

ECONOMICS

These considerations affect the type of equipment and the whole system that is offered to the prospective owner. The economic factors are foremost. They originate from the owner's desire and capacity to invest in an installation that is intended to provide either a minimal or a maximum benefit. It must be determined whether the project is an investment for a quick write-off, a resale or a long term investment. The investor may seek either the lowest first cost, the lowest first cost in balance with the economical owning and operating costs, or strictly the lowest owning and operating costs. Above all the investor is interested in a profitable return on his investment.

PROBLEM

To realize a substantial advantage from an operation of air conditioning in a space or a complete building, the design engineer must consider fundamental situations. He must first define the problem. He must be able to anticipate the behavior of the contemplated air conditioning system. For given conditions of external environment and internal load, the system must integrate with the space or the building which it is to serve. The system must satisfy the maximum instantaneous or actual thermal load* and be operable at any partial load conditions.

The fundamental diagnosis should consider:

1. Investor's financial capacity and the investment objective.
2. Space or building
   a. Purpose
   b. Location
   c. Orientation and shape
3. Coincidental occurrence in external environment of
   a. Temperature
   b. Humidity
   c. Wind
   d. Exposure to sun or other heat exchanges
   e. Shade
4. Diversity of internal load
   a. Occupancy
   b. Lighting
   c. Other heat exchanges
5. Capability for storage of heat gains
6. Necessity and capacity for precooling
7. Physical aspects of space or building to accommodate
   a. Equipment
   b. System
   c. Balanced operation at partial load
8. Customer's concept of environment desired

*Thruout this discussion load shall mean the thermal load of heat gain or loss to or from a building and its content.

INTEGRATION

Each space or building presents an individual problem to resolve. There is no universal solution to a system selection even after it is defined, the physical circumstances evaluated, and the actual load of heating and cooling requirements established. The design engineer must have an appreciation of the structure, its thermal capacity behavior, and the response accorded it by the contemplated system. He must understand the interaction of space or building with external and internal thermal loads and the cancellation of these loads by the system. There should be a full realization that the equipment installed, the control of the air conditioning system, and the building are irrevocably integrated into one whole. To be successful these elements must be coordinated to operate as an entity.

The discussion that follows is a resume of factors that constitute the preliminary qualifications of a project. it offers a guide to the selection of a system best suited to a given circumstance surrounding an application. All types of systems are reviewed briefly, from a self-contained room unit to an elaborate central station system.

The range of systems applications for human comfort is covered from a residence to a high rise apartment building, from the smallest commercial application to a skyscraper or a factory.

SPACE AND BUILDING

OCCUPANCIES

The wide range of spaces and buildings for application of air conditioning for human comfort may be divided into two fields, single-purpose and multipurpose occupancies.

Single–Purpose Occupancies

Single-purpose occupancies involve either an individual or a multitude of individuals gathered for a common purpose of work, prayer, relaxation or amusement. The predominant characteristic is the presence of a single environmental control zone. Examples include a room, residence, or large open area with or without low partitions.

The large area may be an office space, restaurant, beauty salon, etc., at times set in an individual small building. The larger structure may be a church, theater, auditorium or pavilion. The common feature is a building with one or more large open spaces as a major area to be air conditioned.

Multi-Purpose Occupancies

Multi-purpose occupancies involve a multitude of people gathered for various purposes in one or more multi-room, multi-story buildings. These buildings may serve a single purpose: a sale of goods, department store; book lending or collection, a library; a collection of articles of special interest, museum; research, laboratory; learning, school; manufacturing, factory; etc. Generally the multi-room, multi-story buildings may be office buildings, hotels, apartment buildings or hospitals. To the multi-purpose occupancies also belong building compounds of apartment houses, schools, colleges, medical and shopping centers, and factories.

The major characteristic of these occupancies is a multiplicity of environmental control zones served by a single or multiple, preferably central, air conditioning system. With increases in size and number of central station units in a single system, sources of refrigeration and heating are consolidated into one or more large refrigeration and boiler plants.

THERMAL LOAD

When an engineer is faced with an existing space or building, little can be done to alter these structures to aid either the reduction of the air conditioning load or system accommodation unless a major alteration is embarked upon. Definite limiting circumstances may exist.

On the other hand a new building provides freedom and challenge to the architect-engineer team. They may devise a structure that is architecturally and acoustically acceptable and pleasing, at the same time one that incorporates all possible forethought to minimize the air conditioning load. Proper orientation in regard to exposures and analysis of shading (external or internal) is essential. *Space is required for air conditioning equipment and for transmission and distribution of heating-cooling effects.

Building Shell and Outdoors

A building or a space is a thermal container, an enclosure. Within it an air conditioning environment for human comfort is to be maintained, regardless of seasons and outdoor climatic conditions. The considerations involving the construction of a building shell are: thin panel vs massive wall and partial vs total glazing. Other considerations are: glass and wall shading, orientation of the building (simple or complex architecture), height and shape, predominance of peripheral or internal areas, and single zone vs multi-zone application.

*Sun gain thru 150 sq ft of unshaded west glass requires approximately one ton of cooling capacity as against only one tenth of a ton required for the glass with north exposure.

These considerations are pertinent to evaluating the external influences on the air conditioning load of simultaneous occurrence of temperature, humidity, wind and solar conditions. These constitute the outdoor design conditions.

Internal Elements

The selection of the inside design condition for space or building establishes the thermal head against which the air conditioning system will operate at any load condition. The internal load behavior is determined by the diversity factor that can be applied to the population, lights and any heat-pro-ducing or extracting equipment or situation. The smaller the space, the less the diversity; an air conditioning cycle applied to an individual space takes full account of instantaneous load. However, with an increase in the size of a project, the requirements for refrigeration capacity grow. A larger diversity factor may be applied. In most cases the possibility of application of either the heat storage principle or precooling effect should be considered in order to reduce the cooling-heating load (approach the actual load) or reduce the size of equipment.

Part 1 contains information on the evaluation of an air conditioning load. It must be re-emphasized that *an estimate of the actual cooling-heating load is the most fundamental step* before selecting an air conditioning system and equipment. This must be preceded by a thorough survey.

Partial Load

A necessary corollary to the evaluation of actual load is an appraisal of load behavior at partial conditions: possible variations in the internal load; effect of change in external weather elements; reaction of the thermal enclosure and barrier, the structure. The shell's thermal capacity and physical porosity may have great influence on the amplitude of the peaks and valleys in the daily load curves. The system picked for the particular situation must have certain flexibility. Thus the load, the enclosure and the air conditioning equipment in a complete system (total complex) regulates the space environment.

SPACE FOR EQUIPMENT AND SYSTEM

The air conditioning equipment and system auxiliaries require space. The industry is continually devising means and methods to reduce the size of the equipment, the elements of the total system, and their costs, yet produce the same total capacities of cooling and heating at a reasonable investment. Until some radically new approach is discovered, the present means to provide comfort require space.

Self-Contained Units

The extent of space requirements may be small enough to take care of a room unit or a self-contained apparatus within the air conditioned area. Both are types of miniaturized central station plants of small capacity. Such packages contain all the elements to provide complete air conditioning in one enclosure, yet convenient to handle as a unit. The spaces required affect directly the conditioned area; however there may be cases where the units are installed external to the conditioned space.

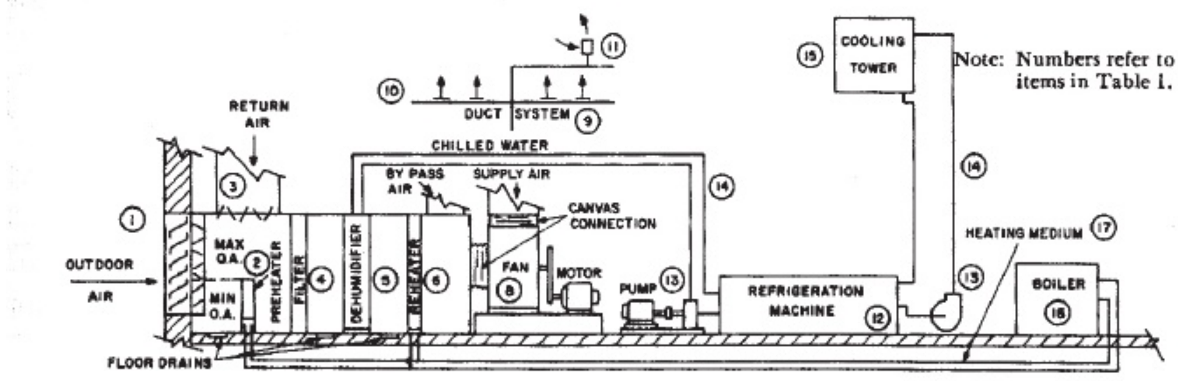


FIG. 1-AIR CONDITIONING PLANT

Central Stations

For a large central station system space has to be provided for conditioning, heating and refrigeration machinery. The cooling-heating media requires space to be transmitted to the conditioning apparatus and then to the areas to be conditioned. There are terminals within the conditioned areas for the final delivery of the cooling-heating effects.

Thus there is a conditioned air path from the out-door air intake thru the apparatus, thru ducts to terminals within the conditioned area; there are refrigeration and boiler plants and interconnecting piping to air handling apparatus and in some systems to terminals *(Fig. 1).* Except for within-the-room terminals the system space required is external to conditioned areas. At times areas that can be utilized more profitably may have to be surrendered for use by some elements of the system.

BASIS FOR DESIGN

The design engineer must make a correct appraisal of the building or space to be conditioned. He must define the problem. He must evaluate the characteristics of the space or building, the climatic environment and the internal heat gains or losses. The evaluation of maximum actual load, its behavior at partial conditions, and the thermal capacity of the enclosing structure are the elements and the foundation to guide the selection of the proper air conditioning system.

QUALIFYING SYSTEM SELECTION

ECONOMICS

Having pointed out the physical aspects and requirements of air conditioning of space and building, a review of the intangible aspects is necessary. These are the customer's concepts of (1) financial involvement and realization of income gain, (2) achievement of the environment of temperature, humidity, air cleanliness, air motion and quietness, (3) realization of flexibility of controls, and (4) insight into limitations of the structure. By clarification of these aspects proper judgment and mutual appreciation between the customer and architect-engineer team is accomplished.

Buyer

The air conditioning market is vast and very competitive. The ultimate user-buyer may be a shrewd investor looking for a quick turnover of capital or a customer who is satisfying a need to neutralize competition that surrounds him, or an owner creating the utmost in monumental progressive design and application.

There are three factors in the economics of system selection: (1) first cost, (2) operating and maintenance costs, and (3) return on an investment. The buyer may be looking for either extreme, the lowest first cost or the lowest operating cost. He may rely on the design engineer to arrive at a balanced proposal. He may desire a monument irrespective of any costs. The design engineer must weigh not only the engineering considerations but the customer's financial attitude and desire for return on the investment.

Investment

One aspect in the economics of selection of an air conditioning system is the actual longevity of equipment and auxiliary components, that is, the write-off life span permitted by the government for depreciation for tax purposes. The net effect is apparent in the analysis of owning and operating costs.

Owning Costs

The owning elements of costs is influenced by the price of the equipment, materials labor and services for an installation. These components must be weighed carefully in arriving at a selection of a system. With an existing building there is an additional element, the interference with regular business.

Operating Expense

Operating costs are influenced by the consumption of energy, whether electrical, steam, gas or other; this is the bulk of operating costs. There is also the item of maintenance consisting of the operating personnel and upkeep of equipment together with supplies of oil, filters and other materials. The equipment working condition is its condition approaching that of the original installation except for the normal duty wear.

The otherwise rentable space given up to accommodate the air conditioning system is also an element in operating costs.

Return on Investment

In the final analysis the rent or any income producing increment is of major interest to the investor. Investment analysis is a gauge for determining whether or not money spent on a proposed project will be wisely invested. It can be used to establish the merits of air conditioning as a sound investment compared with money invested in any other manner.

Investment analysis is the owning and operating cost analysis to determine on a unit basis the incremental cost